A FUNCTIONAL ANALYSIS OF ANOTHER INDIVIDUAL'S BEHAVIOR AS DISCRIMINATIVE STIMULUS FOR A MONKEY

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Key presses of 1 monkey (called the performer) became the basis upon which a 2nd monkey (called the judge) solved conditional-discrimination tasks. First, the performer was trained to press one of two colored choice keys (red or green) depending on the location of a white light in her chamber. The performer's key-pressing behavior was brought under the control of the experimenter by this procedure. Subsequently, the judge was trained to discriminate the performer's key-pressing behavior. In Experiment 1, the judge had to press Key 1 when the performer pressed the red choice key and Key 2 when the performer pressed the green choice key. In Experiment 2, a sample key was introduced. The judge had to press Key 1 when the performer pressed the same colored choice key as the sample; the judge had to press Key 2 when the performer pressed the different colored choice key. In both experiments, the judge was required to attend to the behavior of the performer. It was shown that the performer's behavior served as a discriminative stimulus for the judge's responses in a conditional-discrimination task.

Key words: behavioral stimuli, discriminative stimuli, conditional-discrimination task, key press, monkey

Analysis of the stimulus control of one's behavior by another's behavior provides us with knowledge about the basic processes underlying complex phenomena such as communication and cooperation. Until now some researchers have studied discriminative control by conspecifics' behavior. Danson and Creed (1970) showed that the chain-pulling behavior of a monkey served as a discriminative stimulus for another monkey's responses. Millard (1979) showed that the key-pecking behavior of a pigeon served as a discriminative stimulus for another pigeon's responses. Both studies used multiple schedules. The schedule-controlled behavior of the 1st animal (e.g., the high-rate responding and low-rate responding of the 1st animal) was differentially correlated with the components of multiple schedules for the 2nd animal. These studies demonstrated that the conspecifics' behavior could serve as a discriminative stimulus.

Meanwhile, Hake, Donaldson, and Hyten (1983) used a conditional-discrimination task to analyze discriminative control by conspecifics' behavior in rats. If the 1st rat pressed the upper key in its chamber, the 2nd rat had to press the upper key in its chamber; if the 1st rat pressed its lower key, the 2nd rat had to press its lower key. Using a similar procedure, Mason and Hollis (1962) showed that the location of the 1st monkey's body served as a discriminative stimulus for the 2nd monkey's responses in a conditional-discrimination task. Although the behavior of the 1st animal served as a simple discriminative stimulus for the 2nd animal's responses in the studies using multiple schedules, the behavior of the 1st animal was considered to serve as a conditional discriminative stimulus for the 2nd animal's response in these latter two studies.

More complex discriminative control by conspecifics' behavior was shown in experiments investigating symbolic communication between animals. In these studies, 1 animal performed symbolic matching-to-sample tasks to transmit information to another animal. In the study by Savage-Rumbaugh, Rumbaugh, and Boysen (1978), for example, a chimpanzee was trained to press one of several keys (each key had a different geometric form) depending on the tool he needed for obtaining food. Then

a 2nd chimpanzee provided the 1st chimpanzee with the tool according to the key chosen by the 1st chimpanzee. In the experiment of Epstein, Lanza, and Skinner (1980), 1 pigeon pressed one of the keys that displayed an alphabet character according to the color presented to him, and a 2nd pigeon chose the color key in his chamber according to the key chosen by the 1st pigeon. In these studies, the 1st animal's key-pressing behavior was considered to serve as a conditional discriminative stimulus for the 2nd animal's responses. Furthermore, conditional discriminative stimuli for the 2nd animal's responses were considered to be not only the 1st animal's behavior but also the physical stimuli (i.e., geometric forms or alphabets).

Although which key the 1st animal pressed was considered to be the conditional discriminative stimulus for the 2nd animal's response in these studies, there remained some questionable points. In the study of Epstein et al. (1980), only the key that the 1st pigeon pecked was illuminated in that animal's chamber. In this situation, it was possible for the 2nd pigeon to complete the task by attending only to the illuminated key and not to the 1st pigeon's behavior. Similarly, in the work of Savage-Rumbaugh et al. (1978), because the geometric form chosen by the first chimpanzee was illuminated on the projector, it was possible for the 2nd chimpanzee to complete the task by attending only to the geometric form illuminated on the projector.

The purpose of the present study was to ascertain whether the behavior of 1 monkey (e.g., key pressing) could serve as a discriminative stimulus for a 2nd monkey's behavior in a conditional-discrimination task. It was also asked whether both the 1st monkey's behavior and the physical stimuli (i.e., both the key-pressing behavior and the color stimuli projected on the keys) could serve as discriminative stimuli concurrently in the conditional-discrimination task. In other words, it was ascertained whether "which of the keys that the 1st monkey pressed" could become the basis upon which the 2nd monkey responded. In this manner, the stimulus control by another's behavior shown in previous communication tasks could be reevaluated and the degree of stimulus control exerted by another's behavior in such a complex experimental situation could be explored.

EXPERIMENT 1

METHOD

Subjects

The subjects in this study were 2 experimentally naive female Japanese monkeys (*Macaca fuscata*). They were 4 years old at the beginning of this study. M912 was the judge, and T670 was the performer. Their roles were consistent throughout all experiments. They lived in a group cage with 2 cagemates who were the same age and sex. They had been familiar with each other since the outset of the experiment. The amount of food received by the judge and the performer was controlled to permit them to grow normally during the experiment, a period of 1 year. They were fed after each session.

Apparatus

The apparatus, shown schematically in Figure 1, consisted of two experimental chambers, 70 cm wide by 70 cm long by 70 cm high. The chambers were separated from each other by a 55-cm gap containing a keyboard. The chambers were arranged in mirror image of each other. The wall facing the keyboard (front wall) of each chamber was made of Plexiglas with a slit (30 cm wide by 5 cm high) through which the monkeys could reach the keyboard. A wall adjacent to the front wall of each chamber was made of Plexiglas or bars through which the monkeys could be observed by the experimenter through the monitor. The other adjacent wall contained a food tray. Half of the front wall was covered so that the monkeys could not see the partner's food tray or observe the partner's movements when taking a reinforcer (a piece of apple or a raisin). However, they could observe the partner's use of the keyboard.

Three square keys could be mounted on the keyboard between the two chambers. They were 3 cm by 3 cm and could be illuminated by inline projectors with red or green light. One key was called the sample key, and the other two keys were called the choice keys. These keys were movable and their locations could differ as required by the conditions of the experiments. In Experiment 1, only the choice keys were mounted on the keyboard.

In the performer's chamber, below the slit in the front wall, two square white lights (1 cm by 1 cm) that were visible only to the per-

former could be illuminated. In the judge's chamber, two circular keys were mounted on the wall containing the food tray. These were arranged vertically with the center of the lower key (called Key 1) 15 cm from the floor and that of the upper key (called Key 2) 15 cm above it. Their diameter was 4 cm, and they could be transilluminated by white lights.

During each trial, a light (called the trial light) located about 40 cm above the keyboard, was turned on. A houselight and white noise were on throughout the session. Events were controlled and recorded by electromechanical equipment in an adjacent room.

Procedure

Step 1a. Preliminary training of the performer. To make the performer's key presses discriminative stimuli for the judge, the performer's behavior first had to be brought under the control of the experimenter. Thus, the performer was trained to press the choice keys according to the location of the white light in her chamber (location sample). In this step, only the performer was introduced in the apparatus and only the choice keys were located on the keyboard, 20 cm away from the performer's chamber. Trials began with the onset of the trial light. Two seconds later, the left or right light in the performer's chamber (location sample) was illuminated; one choice key was illuminated red and the other green, with the position for each color determined randomly. The location sample was presented equally often on the left and right. The performer had to press the choice key in front of the location sample to obtain a reinforcer. The reinforcer was delivered after a 2-s delay. Each session consisted of 100 trials. The intertrial interval was 15 s. Color was irrelevant for the performer throughout all the experiments.

Step 1b. Preliminary training of the judge. For Step 1b, the judge alone was in the apparatus, and only the choice keys were mounted on the keyboard (15 cm from the judge's chamber). Each trial began with illumination of the trial light, and 2 s later one of the choice keys was illuminated with a red or green light. A press on the lit key turned it off and illuminated Key 1 and Key 2 in the judge's chamber. If the color of the lit choice key was red, then the judge's resposne to Key 1 was reinforced; if the color of the lit choice key was green, then the judge's response to Key 2 was reinforced.
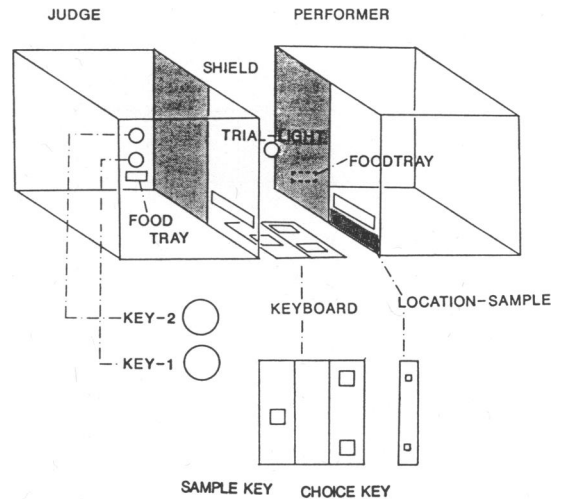

Fig. 1. Diagram of the experimental apparatus.

Initially a single color was used for 10 successive trials. The number of succesive trials with one color was reduced to five and then three, and finally the color on each trial was chosen randomly (with a probability of .5). Each session consisted of 80 trials, and the intertrial interval was 15 s throughout the following steps in Experiment 1.

Step 2. Introduction of the interactive situation. For several sessions before introducing the performer and the judge to the interactive condition, both were brought into their chambers simultaneously for 10-min periods. Following Step 1b, the choice keys were gradually moved closer to the performer's chamber. When the choice keys were 35 cm away from the judge's chamber and the judge could not reach them, the performer was placed in her chamber. Now she, instead of the judge, pressed the choice keys, basing her choice on the location sample. Only one choice key was illuminated with a red or green light, as in Step 1b.

After this training, the procedure was modified so that both choice keys were illuminated, one red and the other green. The performer pressed one of these keys according to the location sample. The number of presses required on the choice key was increased gradually from one to five. The key that the performer pressed was turned off 1 s after the performer finished pressing. The other keylight was turned off as soon as the performer finished pressing. Thus,
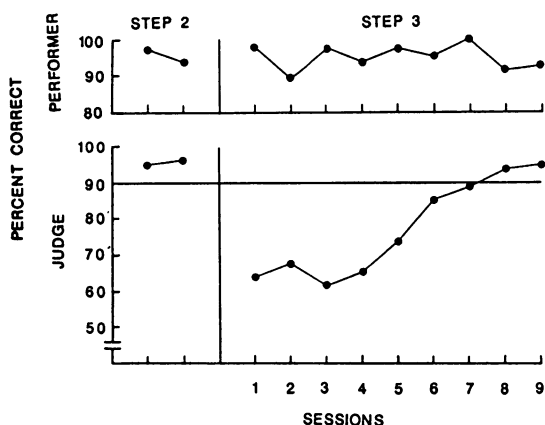
Fig. 2. Percentage correct for the judge's response to Key 1 and Key 2 (lower panel) and for the performer's key presses according to the location sample (upper panel) in the last two sessions of Step 2 and all of Step 3 in Experiment 1.

the judge could complete the task only by observing which key was turned off last. This task required the judge to attend only to the color, not necessarily to the performer's behavior.

The performer's food tray was illuminated immediately after she finished pressing the correct choice key, and reinforcers were delivered to both monkeys at the end of the trial. When the performer pressed the choice key not according to the location sample, all stimuli were turned off and the same trial commenced again after a 15-s timeout. When the judge made an error, all stimuli were turned off and only the performer received food. The same trial commenced after a 15-s timeout.

Step 3. Discrimination of the performer's behavior. In this step, both choice keys remained illuminated for 1 s following the performer's key choice. To respond correctly, the judge had to base her discrimination on whether the performer pressed the red or green key. The judge could do this by observing the movement of the performer's hand; that is, by attending to the performer's behavior.

RESULTS AND DISCUSSION

Following the training given in Step 1a, the performer's accuracy always exceeded the 90% correct criterion except in one session. Training in Step 1a required 52 sessions.

It took 15 sessions for the judge to reach the criterion of more than 90% correct for two consecutive sessions in the preliminary train-

ing (Step 1b). It took 41 sessions for her accuracy to reach the same criterion in the interactive situation (Step 2). Figure 2 shows the percentage of the judge's correct responses and the performer's correct key pressing in the last two sessions of Step 2 and for all the sessions of Step 3. When both choice keys remained illuminated for 1 s following the performer's key pressing (Step 3), the judge's accuracy initially decreased to 60% and then recovered to reach the criterion within nine sessions. This suggests that only the color of the light turned off last controlled the judge's responses at the beginning of Step 3. However, the performer's behavior, together with the color of the light illuminated on the key that the performer pressed, came to control the judge's responding at the end of Step 3.

To complete this task accurately, the judge had to attend both to the performer's key-pressing behavior and to the color of the light projected on the key. Experiment 1 demonstrated that the performer's behavior could become the basis upon which the judge solved the conditional-discrimination task. Furthermore, by attending to both the performer's behavior and the physical stimuli (color of the lights illuminated on the choice key), the judge could report accurately which of the colored keys the performer had pressed.

EXPERIMENT 2

In Experiment 1, the judge was required to report which of the colored keys the performer had pressed by attending to both the performer's key-pressing behavior and the colored light on the choice key. In Experiment 2, the judge was required to solve a more complex conditional-discrimination task. That is, the judge had to respond differentially according to whether or not the performer's choice behavior matched the sample.

METHOD

Subjects and Apparatus

Subjects were the same as in Experiment 1. The apparatus was also the same as in Experiment 1, except that the sample key was located on the keyboard. The sample key was located 20 cm from the judge's chamber, and the choice keys were 20 cm from the performer's chamber. The distance was such that only

the judge could press the sample key and only the performer could press the choice keys.

Procedure

Step 1. Same-different discrimination. Each trial began with illumination of the trial light. Two seconds later, a red or green light was presented on the sample key. Two presses of the sample key by the judge produced only one colored light, red or green, on one of the choice keys as the comparison stimulus and illuminated the location sample light corresponding to the lit choice key in the performer's chamber. The performer pressed one of the choice keys according to the location sample. The number of presses required to the choice key was five. Following this, the two keys in the judge's chamber were illuminated. If the color of the sample and that of the comparison stimulus were the same, the judge's response to Key 1 was reinforced; if the color of the sample and that of the comparison stimulus were different, the judge's response to Key 2 was reinforced. The sample and comparison stimuli were turned off when the judge responded to either Key 1 or Key 2. This task required the judge only to attend to the sample and the comparison stimulus, not necessarily to the performer's behavior.

As in Experiment 1, the performer's food tray was illuminated immediately after she finished pressing the correct choice key, and reinforcers were delivered to both monkeys at the end of the trial. When the performer made an error, all stimuli were turned off, and the same trial commenced after a 15-s timeout. When the judge made an error, all stimuli were turned off, and only the performer received food. The same trial commenced after a 15-s timeout.

In Experiment 2, each session ended when the performer received 96 reinforcers.

Step 2. Discrimination between the performer's matching and nonmatching behavior. The procedure here was identical to that of Step 1 except that both red and green lights were presented simultaneously on the two choice keys and remained illuminated until the judge responded to Key 1 or Key 2. If the performer pressed the choice key displaying the same color as the sample, the matching comparison, the judge's response to Key 1 was reinforced. If the performer pressed the choice key displaying a different color from the sample, the non-matching comparison, the judge's response to

Key 2 was reinforced. For this step, the judge had to discriminate between the performer's matching and nonmatching behavior by attending to both the sample and comparison stimuli and the performer's key-pressing behavior.

RESULTS AND DISCUSSION

It took 41 sessions in Step 1 and 98 sessions in Step 2 for the accuracy of the judge's responses to Key 1 and Key 2 to reach the criterion of greater than 90% correct. Figure 3 shows the percentage of both the judge's and the performer's correct responses in the last two sessions of Step 1 and the first 30 sessions and the last five sessions of Step 2. The judge's accuracy dropped to 60% at the beginning of Step 2. This deterioration in performance suggests that only the physical stimuli (the sample and comparison stimuli) were controlling the judge's responses during Step 1.

To reach the criterion, however, the performer's behavior had to control the judge's responses as discriminative stimuli. Therefore, the judge had to respond differentially according to whether the performer pressed the matching comparison key or the nonmatching comparison key. To complete this task, the judge was required to attend both to the performer's behavior and to the sample and comparison stimuli. Experiment 2 demonstrated that both the performer's behavior and the sample and comparison stimuli could serve concurrently as discriminative stimuli for the judge's responses in a complex conditional-discrimination task. Apparently, the judge reported whether the performer matched or did not match.

GENERAL DISCUSSION

This research demonstrated that the performer's behavior could serve as a discriminative stimulus for the judge's responses in two conditional-discrimination tasks. Furthermore, the judge was able to report whether the performer pressed a red key or a green key and whether the performer did or did not match by attending to both the performer's behavior and the physical stimuli (i.e., colored lights illuminated on the keys).

In these tasks, the performer's behavior and the physical stimuli were considered to function as the conditional discriminative stimuli
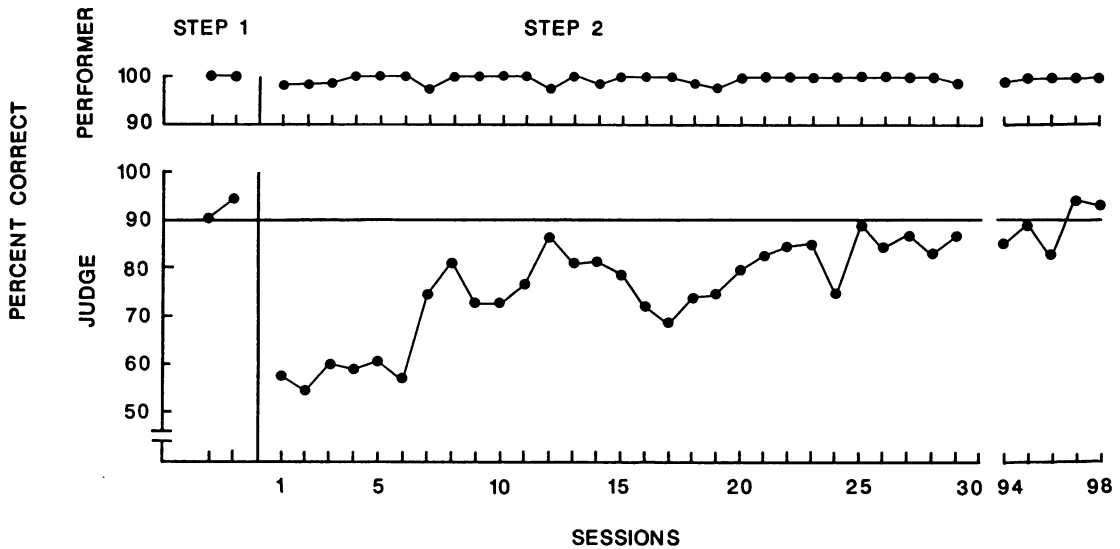
Fig. 3. Percentage correct for the judge's response to Key 1 and Key 2 (lower panel) and for the performer's key presses according to the location sample (upper panel) in the last two sessions of Step 1 and the first 30 sessions and the last five sessions of Step 2 in Experiment 2.

for the judge's responses. In Experiment 1, two stimuli (i.e., the performer's hand on the red lighted choice key and the performer's hand on the green lighted choice key) were considered to control differentially the judge's responses to Key 1 and Key 2. Stimulus control in such a conditional-discrimination task made it possible for the judge to report which of the choice keys the performer had pressed.

In Experiment 2, the stimuli consisted of the sample, the comparison stimuli, and the performer's behavior. The judge had to respond differentially according to a combination of these: For example, when the red sample and the performer's hand on the red lighted choice key were presented, the judge had to respond to Key 1; when the red sample and the performer's hand on the green lighted choice key were presented, the judge had to respond to Key 2. Such stimulus control made it possible for the judge to report whether the performer had matched or not.

Carter and Werner (1978) discussed the nature of stimulus control shown in conditional-discrimination tasks. They suggested three learning models to account for the performance of a pigeon in matching to sample and oddity from sample: a configuration model, a multiple-rule model, and a single-rule model. In the configuration model, a pigeon was conditioned to peck a comparison stimulus according to a set of stimuli, that is, a specific arrangement of sample and comparison stimuli. In the multiple-rule model, a pigeon was conditioned to peck a comparison stimulus according to the specific sample. In the single-rule model, a pigeon was conditioned to peck a comparison stimulus according to whether the comparison matched the sample or not.

These models may be applicable to the control exerted by the conditional discriminative stimuli over the judge's responses in Experiment 2. It is possible that the entire set of stimuli served as conditional discriminative stimuli for the judge's responses to Key 1 and Key 2, consistent with the configuration model. It is also possible that a combination of stimuli such as the sample and the performer's hand on the colored choice key served as the conditional discriminative stimuli for the judge's responses to Key 1 and Key 2. This is an interpretation consistent with the multiple-rule model. If the judge pressed Key 1 or Key 2 according to whether the performer matched or not, then the single-rule model is appropriate to account for the judge's performance.

It is not clear which model provides the most appropriate description of the judge's behavior in the present experiments. Careful tests must be carried out to clarify the possibilities. For example, two sets of new color stimuli could be prepared. In the presence of one set of these

stimuli, the judge is trained to press Key 1 or Key 2 according to the sameness or difference between the sample and a comparison stimulus as in Step 1 of Experiment 2. If the judge can report whether or not the performer has matched when a new set of color stimuli with which the judge has never been trained is presented, the judge's behavior can be described by the single-rule model. If the judge can report whether or not the performer has matched only when the new set of color stimuli (with which the judge has been trained as in Step 1 of Experiment 2) is presented, the multiple-rule model is appropriate to account for the judge's performance. If the judge cannot report whether or not the performer has matched when the new sets of color stimuli are presented, the configuration model provides an appropriate description.

Monkeys, as well as chimpanzees, are useful subjects for such research because of their ability to perform complex conditional-discrimination tasks. Perhaps pigeons will be able to perform similar tasks if reasonable training steps, like those used in the present experiments, are imposed (cf. Epstein et al., 1980). Research investigating stimulus control of one's behavior, either by another's behavior or by the combination of another's behavior and the physical stimuli, may prove informative in the experimental analysis of social behavior, such as communication and cooperation.

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